Irrigated Agriculture on the High Plains: An Uncertain Future

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Recent declines in irrigated acres in the High Plains and shifts to crops which use less water are likely to continue, with an eventual return to dryland production in many regions. Declining groundwater levels and depletion of the Ogallala aquifer are secondary causes of this decline. Primary causes are high irrigation costs and low profitability of irrigated crops relative to dryland crops produced within and outside the region. Continued low commodity prices will speed the transition to dryland production as many current irrigators are unable to replace fully depreciated irrigation systems. Adoption of new technology will slow but not reverse the reduction in irrigated production.

Key words: agriculture, conservation, High Plains, irrigation, Ogallala, technology, tillage.

The High Plains refers to a large land resource area within the Great Plains region of the United States. This paper focuses on the portion of the High Plains in which substantial irrigated acres overlie the Ogallala Formation, a major underground aquifer providing most of the water for the agricultural sector within this region. The Ogallala is essentially a closed basin of unconsolidated sand and gravel, saturated with water deposited over millions of years. There are no underground rivers or streams replenishing the water supply. Water movement within the aquifer is limited. The aquifer is not uniform—depths to water vary from 50 to 250 feet, and saturated thicknesses of water-bearing formation range from 50 feet or less to more than 1,000 feet. The substantial water withdrawals (21 million acre-feet in 1980) associated with expanding irrigated acreage (15 million acres in 1980) have resulted in declines in the water table ranging from 50 feet in many areas to 200 feet in a few areas of the Texas High Plains (High Plains Associates). Annual recharge from rainfall and irrigation percolation has been negligible in most portions of the Ogallala. As water levels decline, irrigation well yields, measured in gallons per minute, decline and the feet of lift required to apply water to crops increase. These forces act, other things equal, to increase pumping costs per acre-foot and per acre and to reduce the profitability of irrigated crop production.

Concern over declining water levels and rapidly rising energy costs in the late 1970s heightened anxiety over the future of irrigated crop production and the agricultural economy of the High Plains region. The U.S. Congress authorized the Economic Development Administration to conduct a $6 million study of the depletion of the Ogallala aquifer and to develop plans to increase water supplies in the area.

The primary purpose of this article is to focus attention on factors which will determine the future economic viability of irrigated production in the High Plains region. There is little on the horizon to change the view that the future will bring a continued decline of irrigated crop production and an eventual return to dryland agriculture. Higher commodity prices and more rapid development and adop-

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tion of cost-reducing and output-increasing technology will lengthen the period over which it is profitable to irrigate. Continued low commodity prices, declining water tables, increasing pumping costs, water quality concerns, and government program incentives could shorten substantially the period over which many producers find irrigation economically feasible. Acreage shifts to lower water-use crops are likely to continue, but consideration of alternative enterprises is discouraged by current government program provisions. Discussion of these topics follows a brief retrospective look at the High Plains Study and the decade of the 1980s.

The High Plains Study

Researchers in the six cooperating states conducted a "baseline" analysis which assumed that state and federal governments would take no purposeful actons to reduce demands on the Ogallala or to augment supplies. For the baseline, typical farming operations were defined by researchers in each state. Current trends in crop yields, adoption of proven irrigation and tillage improvements at the current rate, conservation practices, and water use management practices already in common use were part of the baseline scenario. Future energy and crop prices were provided to state researchers by the project's general contractor. Energy prices were expected to rise rapidly during the early stages (1977 to 1985) of the overall study period (1977–2020) but to moderate thereafter. More important, commodity prices were projected to increase in real (inflation adjusted) terms throughout the study period. Rising real commodity prices were predicated upon the expected continued expansion of world population and the resulting increased pressure on food supplies.

Based on this optimistic future for real commodity prices, perhaps the results of the High Plains Study baseline analysis are not surprising. Rather than declining irrigated acres because of rising energy prices and pumping costs and declining water tables, irrigated acres were actually projected to increase by 3.8 million acres during the forty-year period. However, substantial increases in irrigated acres were projected only for Nebraska. In Kansas and Texas, irrigated acres were projected to decline by a total of 2.6 million acres. Ogallala water reserves were projected to decline by over 700,000 acre-feet between 1977 and 2020, a 23% reduction in water in storage. Acres of the six principal crops in the region were all projected to increase, although changes varied considerably from state to state (High Plains Associates). Sensitivity analyses conducted in all states (but not reported in the final study report) held real commodity prices constant. Substantial reductions in irrigated acres were projected for Oklahoma (Warren et al.) and most of the study area. The critical importance of commodity prices to economic viability of irrigation in the region was apparent from these analyses.

High Plains Agriculture during the 1980s

The decade of the 1980s has been quite different from that envisioned at the time of the High Plains Study. The real increases in agricultural commodity prices which were important determinants of the study results have not occurred. The substantial increases in irrigated acres of corn and soybeans projected for Nebraska have not occurred. Growth in irrigated acres in Nebraska during the mid-1980s is estimated at only 20 to 30 thousand acres per year. Corn continues to be the dominant irrigated crop, partly because government programs provide incentives for producers to protect their feed grain base (Supalla, in a personal conversation in May 1988). The actual decline of 1.6 million irrigated acres in Texas and the apparent reduction in water use have been more substantial than projected in the High Plains Study. A reduction in corn acres in Texas has occurred as projected, but the substantial increase in acres of irrigated wheat was not projected in the High Plains Study (Lansford, Harman, and Musick). In Kansas, recent large reductions in irrigated corn production were not projected to occur by 1985; however, recent increases in production of both wheat and sorghum were projected for the 1980s (Buller). In Colorado, it appears that irrigation continues at near historic levels, with irrigated corn and wheat as the most important crops (Colorado Department of Agriculture). In Oklahoma, irrigated acres overlying the Ogallala aquifer have declined from about 395,000 in 1977 to 221,500 in 1986 (Oklahoma Department of Agriculture). Similar decreases were projected in High Plains Study sensitivity analyses which assumed constant real commodity prices. Acres of irrigated corn and grain sorghum have declined substantially and wheat has replaced corn as the most important irrigated crop in the Oklahoma Panhandle.

The significant reductions in irrigated corn acreage in Kansas, Oklahoma, and Texas appear to have been a result of low corn prices, rising pumping costs caused by escalating energy prices, and increased feet of lift. Producers, ignoring sunk fixed costs, have shifted scarce and expensive irrigation water to wheat and sorghum, which require less water and have had attractive profits relative to irrigated corn. Winter wheat also has provided the opportunity for additional income from cattle grazing. Consideration of alternative crop enterprises has been discouraged by cross-compliance provisions of government commodity programs. To what extent are these recent changes likely to be continued into the 1990s?

Future of the High Plains

During the late 1970s researchers found it difficult to be pessimistic regarding agriculture during the coming decade. Now, pessimism regarding improvements in agriculture during the 1990s is more common than unbridled optimism. Profitability of irrigated and dryland crop production in the High Plains and profitability relative to other regions producing important High Plains crops will be crucial to the future of the High Plains. During the 1980s, low commodity prices have contributed to shifts of acres out of irrigation or to crops such as wheat and sorghum which use less water. Future commodity prices determined by domestic and foreign demand for food grains, feed grains, hay crops, and beef, will be the driving forces determining economic viability of irrigated production in the area. Strong demand caused by increased competitiveness of U.S. agricultural exports, a growing world population, or widespread weather conditions would strengthen the viability of irrigated production. However, if irrigation costs in the High Plains are high, as suspected, and the profitability of irrigated cropping alternatives is low, as suspected, continued low commodity prices will hasten the conversion to dryland. If recent concerns over the quality of groundwater result in reductions in chemical usage or changes in agricultural practices thought to affect water quality, profitability of irrigated production in the High Plains could be adversely affected.

A number of factors contribute to increased viability of irrigation and could act to reduce, but not offset, the potential impact of continued low commodity prices. Offsetting factors include the development and adoption of cost-reducing and/or output-increasing technology, such as low pressure/high efficiency irrigation systems, conservation tillage practices, and biotechnology. Each factor alone will lengthen slightly the time over which irrigation is profitable and, acting in conjunction, could have a significant impact on the economic life of the aquifer. We will return to the technology discussion after investigating irrigation pumping costs and the profitability of irrigated production in the region.

High Irrigation Pumping Costs

In a recent study by Dale et al., capital and operating costs are calculated for alternative irrigation systems in the central Ogallala region. Fixed and variable costs are reported for gated pipe, surge flow, high pressure center pivot, low pressure center pivot, and low energy precision application (LEPA) systems. Calculations are for an average net irrigation application rate of about 15 acre-inches, the average water requirement for a corn, sorghum, wheat rotation (table 1). Variable irrigation costs must be covered in the short run if irrigated production is to continue. In the long run, fixed and variable cost must be covered. For the most favorable situation presented (150 feet of lift and a $2.00 per mcf natural gas price), total irrigation costs per acre range from $69.46 for the surge flow system to $107.73 for the high pressure sprinkler. Under the least favorable price and lift conditions (250 feet of lift and $3.50 per mcf natural gas) total irrigation costs per acre vary from $105.11 for the surge flow system to $147.00 for the high pressure sprinkler. The additional income from irrigated crops must be substantial to cover these costs.

In a similar study in Colorado, Skold and Young calculate break-even water costs under intermediate and long-run economic conditions for favorable and less favorable commodity prices in the Ogallala region. In their intermediate-run scenario, all costs except well

Table 1. Annual Irrigation Costs for Alternative Irrigation Systems, Central Ogallala Region

	Gated-Pipe	Surge-Flow	Hi Pressure Center Pivot	Lo Pressure Center Pivot	LEPA
150-Feet Lift			($)		
Fixed costs:					
$/acre	27.04	29.67	63.00	63.00	68.48
($/acre-inch)	(1.04)	(1.29)	(3.00)	(3.15)	(4.15)
Variable costs ($3.50/mcf):					
$/acre	54.60	51.75	59.64	49.00	40.76
($/acre-inch)	(2.10)	(2.25)	(2.84)	(2.45)	(2.47)
Variable costs ($2.00/mcf):					
$/acre	43.16	39.79	44.73	38.20	33.66
($/acre-inch)	(1.66)	(1.73)	(2.13)	(1.91)	(2.04)
Total costs ($3.50/mcf):					
$/acre	81.64	81.42	122.64	112.00	109.23
($/acre-inch)	(3.14)	(3.54)	(5.84)	(5.60)	(6.62)
Total costs ($2.00/mcf):					
$/acre	70.20	69.46	107.73	101.20	102.14
($/acre-inch)	(2.70)	(3.02)	(5.13)	(5.06)	(6.19)
250-Feet Lift					
Fixed costs:					
$/acre	35.62	38.41	72.87	74.20	77.72
($/acre-inch)	(1.37)	(1.67)	(3.47)	(3.71)	(4.71)
Variable costs ($3.50/mcf):					
$/acre	72.54	66.70	74.13	64.00	51.81
($/acre-inch)	(2.79)	(2.90)	(3.53)	(3.20)	(3.14)
Variable costs ($2.00/mcf):					
$/acre	54.60	50.83	54.18	48.40	40.76
($/acre-inch)	(2.10)	(2.21)	(2.58)	(2.42)	(2.47)
Total costs ($3.50/mcf):					
$/acre	108.16	105.11	147.00	138.20	129.53
($/acre-inch)	(4.16)	(4.57)	(7.00)	(6.91)	(7.85)
Total costs ($2.00/mcf):					
$/acre	90.22	89.24	127.05	122.60	118.48
($/acre-inch)	(3.47)	(3.88)	(6.05)	(6.13)	(7.18)

Source: Dale et al.

and pump amortization must be covered. In the long-run case, well, pump, motor, and distribution system costs must also be covered. Under their less favorable price scenario (alfalfa $63/ton, corn $2.50/bushel, grain sorghum $2.10/bushel, and wheat $3.50/bushel), break-even water costs are $44 for alfalfa, $14 for grain sorghum, $65 for corn, and $110 for wheat. Under assumptions for the long-run scenario, break-even water costs are $17 for alfalfa, $31 for corn, and $26 for wheat. Grain sorghum is unprofitable at any water cost included in the study. The less favorable price scenario appears relatively favorable compared to current crop prices (Skold and Young).

These studies suggest that with current commodity prices and government payments adding to the cash flow, many producers continue to operate existing irrigation systems by covering variable irrigation costs. That is, groundwater irrigation remains profitable in some areas only because producers are living off previously sunk investments in well, pump, and irrigation distribution systems (Skold and Young). Producers will find it difficult to replace existing systems with improved technology and cover both variable and fixed costs over the long run. Given the large investment in the High Plains during the 1970s, a large portion of the capital stock is approaching the end of its useful life. If producers are unable to replace existing irrigation equipment, large reductions in irrigated acres may occur in the near future.

Low Profitability of Irrigated Production

In the coming years, as federal support for commodity programs is reduced, rising irrigation costs are likely to place the High Plains region at a disadvantage compared to other regions with lower irrigation costs or producing favorable yields under dryland conditions. A comparison of production costs per planted acre for corn tends to substantiate this assertion. Table 2 presents production costs per planted acre for corn produced in Colorado, Kansas, Nebraska, and Texas, and for California, Illinois, Indiana, and Iowa from outside the High Plains. Cash receipts do not include government commodity payments. Cash expenses account for the variable inputs (such as seed, fertilizer, fuel, etc.) and are the out-of-pocket expenses incurred during production. Fixed cash expenses include general farm overhead, taxes, insurance, and interest. Cash returns (receipts minus expenses) are calculated before and after a charge for replacing machinery, equipment, and buildings. In the long run, economic (full ownership) costs must be covered if the operator is to continue in production. Full ownership costs include variable cash expenses, general farm overhead, taxes, insurance, and capital replacement, and also impute a return to owned inputs including operating capital, nonland capital, land, and unpaid labor (Davenport). The residual return to management and risk (cash receipts minus full economic costs) is a long-run economic indicator used to compare performance of commodities and to assess relative returns among commodities produced under differing conditions and in different regions.

A comparison of residual returns to management and risk for corn in different states, without government commodity payments, confirms that irrigated corn production in the High Plains is high cost and low return relative to competing states in the Corn Belt. Economic cost per bushel for 1986, calculated by dividing full economic cost by yield in bushels per planted acre, suggests that the Corn Belt states have a \$.30 to \$.70 per bushel cost advantage in the production of corn over Colorado, Kansas, and Texas. Their cost advantage is only \$.10 to \$.25 per bushel over Nebraska. If irrigation pumping costs continue to rise more rapidly than costs of other inputs, the cost of production advantage in the Corn Belt is likely to increase in future years. If so, the decreases

Table 2. Production Costs per Planted Acre, Selected States

Item	Colorado Irrigated Corn	Kansas Irrigated Corn	Nebraska Irrigated Corn	Texas Irrigated Corn	California Irrigated Corn	Illinois Dryland Corn	Indiana Dryland Corn	Iowa Dryland Corn
Cash receipts	219.36	221.70	203.00	279.93	332.68	186.93	169.90	166.71
Cash expenses								
Variable cash expenses	165.71	205.87	144.41	234.82	206.80	134.83	118.76	115.71
Fixed cash expenses	95.15	91.83	99.40	62.45	131.79	73.87	63.62	70.28
Total cash expenses	260.86	297.70	243.81	297.27	338.59	208.71	182.38	185.99
Receipts less cash expenses	−41.50	−76.00	−40.81	−17.34	−5.91	−21.78	−12.48	−19.28
Capital replacement	49.49	58.27	51.73	43.53	50.52	35.07	33.62	34.83
Receipts less expenses and replacement	−90.99	−134.27	−92.54	−60.87	−56.43	−56.85	−46.10	−54.11
Economic (full ownership) costs	316.77	369.07	293.22	392.86	455.58	255.07	242.03	247.04
Residual returns to management and risk	−97.47	−147.37	−90.22	−112.93	−122.90	−68.14	−72.13	−80.33
Harvest-period price (\$/bu)	1.60	1.49	1.45	1.90	2.25	1.39	1.40	1.24
Yield (bu/planted acre)	137.10	148.79	140.00	147.33	147.86	134.48	121.36	134.44
Economic cost per bushel	2.31	2.48	2.09	2.67	3.08	1.90	1.99	1.84

Source: Davenport.

in irrigated corn acres observed in recent years in Colorado, Kansas, Oklahoma, and Texas are likely to continue.

The Potential Impact of New Technology

The creation and adoption of innovative technology has helped make High Plains agriculture competitive. Continued adoption of irrigation and tillage technology, and the eventual development of significant biotechnology, offer some hope to area producers that they can survive periods of low commodity prices and rising energy costs. To the extent that these technologies improve profitability, they may lengthen the economic life of the Ogallala aquifer.

Irrigation technology. Rising irrigation costs provide incentives for producers to adopt irrigation technology and production practices which reduce water use. Water-saving irrigation technology includes low pressure irrigation sprinklers; the low energy precision application (LEPA) system; improved surface systems, including surge flow, alternate row irrigation, precision land leveling, automated gated pipe, and tailwater recovery systems; and irrigation scheduling and deficit irrigation techniques.

Considerable research has been conducted on water-conserving irrigation technology. Irrigation efficiencies vary for different types of systems, depending upon application rates, crops, soil type, and field slope but are typically in the range of 40% to 60% for surface or gravity flow systems, 75% to 85% for improved surface or gravity systems, 75% to 85% for sprinkler systems, and 90% to 98% for LEPA systems used with furrow dikes (Sloggett and Dickason). Low pressure irrigation systems require less energy and, other things equal, decrease irrigation costs. The LEPA irrigation system offers tremendous efficiency gains by distributing water through drop tubes and low pressure emitters directly into the furrow at pressures of five to ten pounds per square inch (Lyle and Bordovsky). Furrow diking can prevent irrigation and rainfall runoff, conserve energy, and prevent soil loss (Wistrand). The conversion from low pressure sprinkler to LEPA has been found profitable with or without furrow dikes under a wide range of prices (Lloyd; Robinson; Stoecker, Seidmann, and Lloyd). Alternate furrow irrigation has been found to utilize about 50% of the water required in conventional furrow irrigation while maintaining yields for grain sorghum in Oklahoma. Alternative furrow irrigation and furrow dikes in the nonirrigated rows have been combined to significantly increase yields for cotton and grain sorghum in Texas (Lyle and Dixon). In addition, irrigation scheduling offers the potential to reduce the amount of irrigation water applied and, by proper timing of applications, maintain crop yields (Harris and Mapp; Hornbaker and Mapp). Impediments to widespread adoption of these techniques include lack of producer experience and capital constraints.

Tillage technology. Changes in irrigation technology are often performed in conjunction with changes in tillage practices and vice versa. Practices which retain water in the field and use water more efficiently include leveling, contour benches, terracing, furrow diking, and limited tillage practices. Limited tillage practices in widespread use generally involve reducing the number of field operations (including the elimination or substantial reduction of moldboard plowing), leaving stubble from the previous crop on the surface to reduce wind erosion and soil water evaporation, and greater use of herbicides to control weeds (Office of Technology Assessment 1982).

Considerable research has been conducted in recent years evaluating conservation tillage techniques (Hayes; Greb, Smika, and Black; Unger, Allen, and Wiese; Johnson et al.; Harman et al.). If results from these and other economic studies are confirmed over the longer run, the conversion to reduced tillage and no-tillage practices, particularly in conjunction with crop rotations, will likely become more widespread in the future. It is difficult to say, based on these studies, whether conservation tillage is more profitable than conventional tillage or whether it favors dryland or irrigated production. Many of the practices are effective only under certain soil and/or climatic conditions and may yield little or no improvement where site conditions are not appropriate. Some practices require investments in equipment and machinery and increased expenses for operating inputs and labor. Costs may outweigh the economic benefits of adoption.

There is concern that when reduced tillage is combined with water-efficient irrigation methods, runoff will be reduced and water infiltration and the potential for contamination of groundwater by agricultural chemicals will increase (Office of Technology Assessment 1984). However, the relationships are not well understood and may vary widely from area to area. Nielsen and Lee found little evidence of potential for groundwater contamination from pesticide use, or pesticides found in groundwater caused by agricultural practices, in the High Plains. However, they did find that groundwater contamination from nitrate-nitrogen appears to be concentrated in the central Great Plains, in addition to several other areas of the West. It is unknown how much of the contamination results from agricultural practices.

Some groups have suggested that eligibility for all federal government farm assistance and cost-sharing programs be tied to the use of best management practices, which take water quality into consideration. Adoption of such practices would have a significant impact on irrigated agriculture on the High Plains. However, one suspects that the High Plains would not be adversely affected relative to other regions of the country, such as the Corn Belt, where soil erosion and the potential for groundwater contamination are more substantial.

Biotechnology. Over the next fifteen to twenty years, farm operators will be offered an extensive array of new biotechnology and information technology that could revolutionize animal and plant production (Office of Technology Assessment 1986). The immediate impact of these technologies is expected to be felt first in animal production. The major impacts on plant production are expected to take longer, but anticipated technical advances will allow disease and insect resistance, higher production of protein, and self-production of fertilizer and herbicide (Office of Technology Assessment 1986).

The potential impacts of plant biotechnology on the High Plains region are difficult to assess. Available data do not distinguish expected rates of yield increase on dryland versus irrigated crop varieties, nor do they indicate whether varieties suited to certain regions of the country are likely to experience more or less rapid yield increases. In recent years, irrigated wheat yields in the High Plains have shown greater percentage increases than dryland yields. If, through biotechnology, irrigated yields increase more rapidly than dryland, the long-run competitive position of irrigated agriculture in the High Plains region will be enhanced.

The general hypothesis regarding adoption of water-efficient technology is that annual water withdrawals will decline and the life of exhaustible underground aquifers will be extended. In a study of the effects of technology adoption on agriculture in the Texas High Plains, Ellis, Lacewell, and Reneau report that new technology, especially improved furrow and LEPA distribution systems, will not significantly extend the life of the Ogallala aquifer in that area. Adoption of the new technology lowers the per unit cost of obtaining and distributing ground water but results in constant or even greater annual water use. With lower per unit pumping costs, somewhat more water can be withdrawn profitably from the aquifer, possibly resulting in a slight extension of the economic life of the aquifer (Ellis, Lacewell, and Reneau).

Thus, it appears that new irrigation technology and tillage practices will lower variable pumping costs and perhaps increase crop yields. The substantial fixed costs associated with purchase of a new irrigation system will be avoided by many because much of the new technology can be adopted incrementally by making adjustments on existing irrigation systems and equipment. It seems likely that many early adopters of new technology will find ways to continue irrigated production in the short to intermediate run despite rising pumping costs. However, without rising commodity prices and increased profitability, long-run trends toward dryland agriculture will continue.

Concluding Comments

The decade of the 1980s has seen a substantial reduction in irrigated acres on the High Plains as profitability of irrigated production has been squeezed by low commodity prices and rising irrigation costs. On the acres remaining in irrigated production, substantial shifts have occurred from corn, an intensive water use crop, to wheat and sorghum, which use irrigation water more efficiently. Possible shifts to alternative enterprises have been discouraged by government program cross-compliance provisions.

The central theme of this article is that the future holds a continued decline of irrigated crop production and an eventual return to dryland production in many portions of the High Plains. Declining groundwater levels and depletion of the Ogallala aquifer are secondary, rather than primary, causes of this decline. More importantly, irrigation on the High Plains is expensive, and the profitability of intensively irrigated crops is low relative to dryland crop alternatives within the region as well as in the Corn Belt. Continued low commodity prices will speed the transition to dryland production as many current irrigators are unable to replace fully depreciated irrigation wells and distribution systems.

Rising irrigation costs provide incentives for producers to adopt irrigation technology and tillage practices which reduce water use. The substantial fixed costs associated with purchase of new irrigation systems will be avoided by many because much of the new technology can be adopted incrementally by modifying existing irrigation systems. Early adopters of new technology will likely continue irrigated production as per unit costs of irrigation water are reduced. With lower irrigation costs, incentives exist to increase irrigated acres and withdraw more water from the Ogallala. However, without rising real commodity prices and increased profitability, the established trend toward dryland agriculture on the High Plains will continue.

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